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(54) MAGNETIC RECORDING AND REPRODUCING DEVICE AND  
METHOD FOR PROCESSING ITS REGENERATIVE SIGNAL

(57)Abstract:

PURPOSE: To simplify a circuit and to provide a signal processing circuit easy for making an IC by containing equalizing operation equal to the waveform processing of a partial response(PR) in the circuit configuration of an automatic equalizer.

CONSTITUTION: A memory 16, a pattern converter 15 and an equalization error calculation part 4 are added to a regenerative signal processing circuit 3. A specified recording pattern for setting the characteristic of the automatic equalizer 12 is recorded in the memory 16. By the pattern converter 15, the recording pattern in the memory 16 is converted to an equalization target pattern equal to the equalization waveform after waveform-processing of the

PR. Then by the equalization error calculation part 4, the output error of the automatic equalizer 12 is calculated with the equalization target pattern output of the pattern converter 15 and the constant setting of the automatic equalizer 12 is controlled so that the error is reduced. Thus, the characteristic of the equalizer 12 is set to an equalization characteristic containing the characteristic of the PR waveform processed forcedly initially and thereafter followed up to the fluctuation of the characteristic adaptively.

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#### CLAIMS

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[Claim(s)]

[Claim 1] In the magnetic recorder and reproducing device which has the

regenerative-signal processing circuit which obtains the input from the magnetic head and outputs playback data through an amplifier circuit, an automatic equalizer, and a discrimination circuit. The memory which records the specific record pattern for setting up the property of the above-mentioned automatic equalizer, The pattern converter changed into the identification target pattern equivalent to the identification wave after wave processing of a partial response from the record pattern of this memory, Include an identification error calculation means to control the parameter input of an automatic equalizer to compute the output error of the above-mentioned automatic equalizer with the identification target pattern output of this pattern converter, and to lessen this error. The magnetic recorder and reproducing device which adds the identification means equivalent to wave processing of a partial response to the above-mentioned regenerative-signal processing circuit, and is characterized by constituting including the identification means which is equivalent to wave processing of the above-mentioned partial response at the circuitry of the above-mentioned automatic equalizer.

[Claim 2] The magnetic recorder and reproducing device characterized by having the discrimination circuit of a digital configuration which prepares an A/D-conversion circuit between discrimination circuits in the latter part of an automatic equalizer, and identifies playback data in a magnetic recorder and reproducing device according to claim 1 using a digital signal.

[Claim 3] The magnetic recorder and reproducing device which prepares the simple discrimination circuit which outputs a discernment result to the output of an automatic equalizer for every bit in a magnetic recorder and reproducing device according to claim 2, and is characterized by using for calculation of an identification error and amending the property of an automatic equalizer serially by using the output of this simple discrimination circuit as an identification target pattern at the time of playback of data.

[Claim 4] The magnetic recorder and reproducing device characterized by establishing an A/D-conversion circuit in the preceding paragraph of an automatic equalizer, and having an automatic equalizer using a digital signal in the magnetic recorder and reproducing device of claim 1.

[Claim 5] The magnetic recorder and reproducing device characterized by

having a means to connect with an automatic equalizer, to prepare constant memory further in a magnetic recorder and reproducing device given in any of claim 1 thru/or claim 4 they are, and to set up the identification constant of an automatic equalizer by the memory constant recorded on this constant memory, or to update the contents of constant memory by renewal of the identification constant of an automatic equalizer.

[Claim 6] The magnetic recorder and reproducing device characterized by setting the number of taps of an automatic equalizer as even number in a magnetic recorder and reproducing device given in any of claim 1 thru/or claim 5 they are.

[Claim 7] The magnetic recorder and reproducing device characterized by integrating the above-mentioned regenerative-signal processing circuit with the circuitry of the automatic equalizer which includes the identification means equivalent to wave processing of the above-mentioned partial response in a magnetic recorder and reproducing device given in any of claim 1 thru/or claim 6 they are.

[Claim 8] The regenerative-signal art of the magnetic recorder and reproducing device characterized by including the above-mentioned identification processing in one automatic equalization processing, and performing it by the following in regenerative-signal processing of a magnetic recorder and reproducing device in which it has the identification equivalent to wave processing of a partial response, and the identification which follows other property fluctuation etc. in identification processing.

(1) An automatic equalizer amends identification properties including the property of wave processing of a partial response so that an identification error may decrease. (2) identification error which identifies the amended identification output by the discrimination circuit, and obtains playback data output subtracts and calculates the pattern value which serves as an identification target from the output value of an automatic equalizer. (3) The pattern value with which the pattern value used as an identification target is equivalent to the identification wave after wave processing of a partial response at the time of initialization is chosen. The pattern value equivalent to the identification wave after wave processing of (4) partial responses from

which the output of a discrimination circuit is chosen at the time of subsequent adaptation actuation records the specific record pattern for initializing the property of an automatic equalizer on memory, and changes and asks for the record pattern of this memory.

[Claim 9] The regenerative-signal art of the magnetic recorder and reproducing device characterized by performing a setup of an identification constant by the following using the constant memory which connected to the automatic equalizer and was prepared in the regenerative-signal art of a magnetic recorder and reproducing device according to claim 8.

(1) Record on constant memory in quest of the constant of an automatic equalizer, reproducing the information recorded by the known pattern, read the above-mentioned constant memory at the time of playback of data, and reset as an identification constant at it. Or the identification constant which reset from the contents of the (2) above-mentioned constant memory is updated reproducing data, it is at the playback actuation termination time, and the contents of constant memory are rewritten.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the suitable regenerative apparatus for IC-izing which related to the regenerative-signal processing technique of a magnetic recorder and reproducing device, especially included wave processing of a partial response in automatic equalization, and its regenerative-signal art.

[0002]

[Description of the Prior Art] Application of the signal-transmission technique of the partial response (it abbreviates to PR hereafter) taken up in the communication link field is advanced to the record playback technique of a

magnetic disk drive. About the narrow-band-ized technique of changing one information into two or more sampled value, this uses this technique for magnetic recording, compresses and records the band of a record signal, and identifies the signal of a narrow-band with two or more thresholds.

Conventionally, PR wave processing was realized by the fixed equalizer as indicated by JP,2-150114,A. The regenerative-signal processing circuit which applied this conventional circuit is shown in drawing 7 . the electromagnetism according to change of a truck location etc. after this circuit carries out identification which is equivalent to PR wave processing in the preceding paragraph of digital automatic equalizer 12' with a fixed equalizer 8 -- property fluctuation of a conversion system is absorbed by setting up the property of an AGC circuit and equalizer 12' automatically, and it decodes by the discrimination circuit 13 which consists of the Viterbi decoder. That is, the function of PR wave processing is not included in automatic equalizer 12'. By applying such automatic equalization, the degree of freedom of a design of a circuit can be expanded and it is supposed that the cost of equipment can be reduced as the result. However, the notch in wave-like slimming and a specific frequency and the complicated property which includes noise rejection etc. further were required, components, such as an operational amplifier, a mass capacitor, and an inductance, were indispensable to the implementation, and IC-izing after including these was very difficult for the fixed equalizer 8 which performs identification equivalent to PR wave processing.

[0003]

[Problem(s) to be Solved by the Invention] As mentioned above, in the conventional technique, it could not say that viewpoints, such as simplification of a circuit and IC-izing, were enough as consideration, but there was a problem which makes especially IC-ization difficult. In this invention, it aims at offering a scale, a magnetic recorder and reproducing device with easy IC-izing, and its regenerative-signal art for simplification of a circuit in signal processing including wave processing of PR.

[0004]

[Means for Solving the Problem] In order to attain the above-mentioned

purpose, the magnetic recorder and reproducing device of this invention For example, the memory 16 which records the specific record pattern for setting up the property of an automatic equalizer 12 as shown in drawing 1 , The pattern converter 15 changed into the identification target pattern equivalent to the identification wave after wave processing of PR from the record pattern of this memory, Include an identification error calculation means 4 to control the parameter input of an automatic equalizer to compute the output error of the above-mentioned automatic equalizer with the identification target pattern output of this pattern converter, and to lessen this error. The identification means equivalent to wave processing of PR is added to the above-mentioned regenerative-signal processing circuit 3, and suppose that it constitutes in the circuitry of the above-mentioned automatic equalizer including the identification equivalent to wave processing of Above PR. That is, the automatic equalizer in this invention is the description with fundamental having a configuration including the identification actuation equivalent to wave processing of not only the conventional identification actuation but the above-mentioned PR which follow the property fluctuation of equipment which can be set working, and having made the configuration of the conventional fixed equalizer unnecessary. Like drawing 2 , the A/D-conversion circuit 11 is formed between discrimination circuits in the latter part of an automatic equalizer 12, the discrimination circuit of the high performance handling having the discrimination circuit of a digital configuration which identifies playback data using a digital signal, then a digital signal can be applied here, and it is desirable. Or if the simple discrimination circuit 17 which outputs a discernment result for every bit is formed in the output of an automatic equalizer 12 like drawing 3 , it uses for calculation of an identification error in this case by using the output of this simple discrimination circuit 17 as an identification target pattern at the time of playback of data and the property of an automatic equalizer is amended serially, a discernment function can be followed further at a high speed.

[0005] Or, for example like drawing 4 , the A/D-conversion circuit 11 is established in the preceding paragraph of an automatic equalizer 12, having an automatic equalizer using a digital signal, then an automatic equalizer or

subsequent ones can be digitized, and a miniaturization becomes easy. Or as shown, for example in drawing 5 , further, connect with an automatic equalizer 12 and the constant memory 18 is formed. The identification constant of an automatic equalizer 12 is set up by the memory constant recorded on the above-mentioned constant memory 18. Or if it has a means like the counter group 23 holding the constant in drawing 6 as a means to update the contents of the constant memory 18 by renewal of the identification constant of an automatic equalizer 12 and is made to carry out renewal of a setup of the constant. The advantage of effective and diversification use of memory arises as the memory for parameter input is added, or there is an advantage, such as becoming easy to update an identification constant again corresponding to a change of a magnetic-recording reversion system with time, for example. Here, since PR wave processing is included and the constant near a center tap becomes equal, the number of taps of an automatic equalizer is good to set it as even number, and identification with a high precision becomes easy to obtain and is desirable [ the number ]. And by integrating the above-mentioned regenerative-signal processing circuit with the circuitry of an automatic equalizer including the identification means equivalent to wave processing of above-mentioned PR, it is miniaturized not only as these digital disposal circuits but as a magnetic recorder and reproducing device, and cost is also reduced.

[0006] Or in order to attain the further above-mentioned purpose, suppose that the identification processing equivalent to wave processing of PR is included in one automatic equalization processing, and is performed by the following in the regenerative-signal art of a magnetic recorder and reproducing device in this invention.

(1) An automatic equalizer amends identification properties including the property of wave processing of PR so that an identification error may decrease. (2) identification error which identifies the amended identification output by the discrimination circuit, and obtains playback data output subtracts and calculates the pattern value which serves as an identification target from the output value of an automatic equalizer. (3) The pattern value with which the pattern value used as an identification target is equivalent to



the identification wave after wave processing of PR at the time of initialization is chosen. The pattern value equivalent to the identification wave after wave processing of (4) PR from which the output of a discrimination circuit is chosen at the time of subsequent adaptation actuation records the specific record pattern for initializing the property of an automatic equalizer on memory, and changes and asks for the record pattern of this memory. In the regenerative-signal art in this case, it is desirable as a regenerative-signal art which has an advantage corresponding to performing a setup of an identification constant as follows using the constant memory which connected to the automatic equalizer and was prepared, then the equipment configuration of aforementioned this invention using constant memory. That is, in quest of the constant of an automatic equalizer, it records on constant memory, reproducing the information recorded by the pattern of (1) known, and the above-mentioned constant memory is read at the time of playback of data, and it resets as an identification constant at it. According to this approach, it becomes unnecessary to save the information recorded by the known pattern in the memory data of an automatic equalization means, and after initialization can use it effective in user data memory etc. Or the identification constant which reset from the contents of the (2) above-mentioned constant memory is updated reproducing data, it is at the playback actuation termination time, and the contents of constant memory are rewritten. This approach makes easy correspondence of updating to fluctuation with the passage of time etc.

[0007]

[Function] This invention equalizes the identification of the regenerative signal from the magnetic head automatically also including PR wave processing paying attention to PR wave processing being linearity processing. That is, by this invention, this is included in the configuration of one automatic equalizer there that what is necessary is to follow the property fluctuation at the time of adaptation actuation, and just to carry out identification processing after that after carrying out identification which is equivalent to PR wave processing by initial setting. It is necessary to add the identification error calculation means 4 grade which computes the output error of an automatic equalizer with 16 in

the memory, for example, drawing 1 , which records a specific record pattern especially as an identification means equivalent to PR wave processing, the pattern converter 15 changed into an identification target pattern from the record pattern of this memory, and this identification target pattern output, and controls the parameter input of an automatic equalizer in this configuration to a regenerative-signal processing circuit. the electromagnetism accompanying fluctuation of the truck location on a record medium in the memory and PR pattern converter which constitute the principal part -- because pattern conversion is simply carried out from memory data excluding complicated elements, such as a problem of a conversion system, the configuration does not require double \*\*. That is, an about 2-bit adder can constitute from this memory also by max, using digital memory as memory. Instead of adding such an easy component, the need of the conventional fixed equalizer is lost and it stops on the other hand, needing the operational amplifier for noise rejection etc., a mass capacitor, an inductance, etc. for the notch in wave-like slimming which was conventionally needed for the fixed equalizer for this reason, and a specific frequency, and a pan in this invention. By the above, by this invention, circuitry is simplified fundamentally, IC-ization is also attained and cost reduction is brought about.

[0008] It is this invention, and it not only makes IC-ization advantageous, but further, it simplifies a circuit further by digitization by use of an A/D converter, and high performance-ization is attained by use of the below-mentioned maximum-likelihood-decoding machine etc. It is also possible to deal with improvement in the adaptation rate in that case by adoption of the simple discrimination circuit of this invention etc.

[0009] According to this invention prepared apart from the memory for storage of the specific pattern for initial setting, the memory for a setup of the identification constant of an automatic equalizer, and updating Presetting actuation which initializes the property of an equalizer is carried out off-line, and it records on constant memory. At the time of playback of data The presetting data beforehand recorded by resetting the identification constant for which it asked off-line for initial setting are eliminable after asking for an identification constant. Effective and diversification use of memory -- user data

can be recorded now also on this part -- are brought about.

[0010] Since the tap constant of an equalizer becomes almost equal near the center tap, it makes the number of taps even number regardless of the analog configuration of an equalizer, and a digital configuration, and, thereby, identification with a high precision becomes easy to realize it, when the equalizer of a transversal mold realizes an automatic equalizer including PR wave processing of this invention easily.

[0011]

[Example] The example of this invention is shown in drawing 1 . The regenerative-signal processing circuit 3 which consists of the pre amplifier 7 which amplifies the regenerative signal from a head 2, AGC circuit 9, LPF10, a discrimination circuit 13, and an automatic equalizer 12 into which a property is automatically changed so that an identification error may decrease, The property of an equalizer The specific record pattern for initializing The presetting pattern record memory 16 to record, The identification target pattern change-over section 5 which consists of a PR pattern converter 15 which changes a presetting pattern into the pattern equivalent to the identification wave after PR wave processing, and a pattern change-over machine 14 which chooses a presetting pattern only at the time of initialization of an equalizer, It consists of an identification output, the identification error calculation section 4 which searches for an identification error from an identification target pattern, and the phase simulation signal generation section 6 which generates a system clock from an identification output. The regenerative signal from the magnetic head 2 is amplified by pre amplifier 7 and AGC circuit 9, and an unnecessary band is removed by LPF10. At this time, the negative feedback control of the gain of AGC circuit 9 is carried out so that the amplitude of an identification output may be set to level required for discernment. An automatic equalizer 12 amends identification properties including the property of PR wave processing so that the identification error searched for with a means to mention later may decrease, and it reproduces the data currently recorded by the latter discrimination circuit 13. The above-mentioned identification error subtracts the pattern value which serves as an identification target from the output value of an equalizer, and is searched for.

The output of PR pattern transducer 15 is chosen at the time of initialization, and, as for the pattern value used as the identification target at this time, the output of a discrimination circuit 13 is chosen at the time of subsequent adaptation actuation. The property of an equalizer 12 is set as the identification property which included the property of PR wave processing in early stages compulsorily by this, and can follow property fluctuation accommodative after that by it.

[0012] The 2nd example of this invention is explained using drawing 2 . The regenerative signal from the magnetic head 2 is amplified by pre amplifier 7 and AGC circuit 9, and an unnecessary band is removed by LPF10. Furthermore, this signal is inputted into an equalizer 12, has identification properties including the property of PR wave processing amended, and is digitized with latter A/D converter 11 so that the identification error searched for with the same means as the case of drawing 1 may decrease. This signal is outputted by the discrimination circuits 13, such as a maximum-likelihood-decoding machine, as playback data. At this time, the negative feedback control of the gain of AGC circuit 9 is carried out so that the output of A/D converter 11 may be set to level required for discernment. Other configurations and actuation are the same as drawing 1 . According to this example, by forming A/D converter 11 in an identification output, application of a maximum-likelihood-decoding machine becomes easy, and improvement in the equipment engine performance can be expected.

[0013] The 3rd example of this invention is explained using drawing 3 . Since many parts are the same as that of drawing 2 , only difference is explained. In this example, the simple discrimination circuit 17 which identifies for every bit to the output of an equalizer 12 is formed, and this is inputted into the identification target pattern change-over section 5 instead of the output of the digital discrimination circuit 13. When a maximum-likelihood-decoding machine is adopted as a discrimination circuit 13, the problem that the time amount for several [ at least ] bits is required by the output of a discernment result from a discernment entry of data, and rapid fluctuation of a property cannot be followed arises, but according to this example, since calculation of the identification error at the time of adaptation actuation is called for one by

one, fluctuation of a property can be followed at a high speed.

[0014] The 4th example of this invention is explained using drawing 4 . Since many parts are the same as that of drawing 2 , only difference is explained. In this example, A/D converter 11 is formed in the latter part of LPF10, and an automatic equalizer 12 is also digitized. According to this example, all latter circuits can be digitized from an automatic equalizer 12, the miniaturization of a circuit part becomes it very easy "To come", and equipment cost can be reduced greatly. Moreover, since the output signal of LPF10 has few high frequency components, the error of the sampled value by the sample signal of A/D conversion carrying out a jitter can be made small. Moreover, when a comparable sample jitter can be permitted, it can simplify also digitizing the LPF section of the phase simulation signal generation section 6 interior etc. Usually, the equalizer using a sampled value is weak for the error of a sample phase. For this reason, when external noise is overlapped on a sample signal, it has remarkable effect on an identification wave. Then, in order to avoid the effect of external noise, A/D converter 11 and the phase simulation signal generation section 6 are formed in the same IC.

[0015] The 5th example of this invention is explained using drawing 5 and drawing 6 . Since many parts are the same as that of drawing 2 , only difference is explained. Drawing 5 is drawing showing the whole this example configuration. In this example, the constant of an equalizer 12 is initialized to the time of shipment, or a power up. When initializing an identification constant at the time of shipment, for every plurality of every truck on a magnetic disk 1, every sector and a truck, or a sector, presetting information is recorded, and it asks for an identification constant, reproducing this, and the memory 18 which memorizes the constant is formed. It is the configuration which accesses this memory 18 just before playback of data, and is set as an equalizer 12. In this case, the presetting information after initial setting is completed may be eliminated. When initializing to a power up, presetting information is recorded on the part for every plurality of every truck on a magnetic disk 1, every sector and a truck, or a sector, and memory 18 is reset to a power up. In addition, when an identification constant is made to update accommodative and playback actuation is completed in any case, reproducing

data, the updated constant may be rewritten in memory 18. Moreover, memory 18 is electrically good also as nonvolatile memory which can be written in.

[0016] Drawing 6 is drawing showing the configuration of the automatic equalizer 12 of this example. They are a multiplier and same number \*\*\*\*\* so that it may be the counter group in which the multiplier which constituted 20 in the delay element between each tap of an equalizer, and constituted 21 about each tap, and 22 hold an adder in this drawing, and 23 holds the identification constant and the counter may control this corresponding to the multiplier of 21. 24 is a constant amendment means to calculate the updating value of a constant. Since the equalizer of this invention includes PR wave processing and the constant near a center tap becomes almost equal, the number of taps is made into even number. The input signal 25 and the identification error 28 of an equalizer are inputted into a constant amendment means 24 to calculate the updating value of a constant, and rise/down signal 30 of an identification constant is acquired from the sign of the input signal 25 of an equalizer, and the sign of the identification error 28 for it here. Although not displayed on illustration, this signal is established corresponding to each counter. This signal updates a constant by rising/downing the counter holding an identification constant. The counter group 23 holding a constant sets up and updates the identification constant of an automatic equalizer by the constant which was connected to the memory 18 which is recording the identification constant with the bi-directional bus 27, and recorded the identification constant of an automatic equalizer on constant memory, or was recorded on constant memory. According to this example, an identification constant is only set up from memory 18, and playback of data is possible immediately. It becomes unnecessary moreover, to re-store data for every powering on by making memory 18 into the nonvolatile memory which can be written in electrically. When initializing furthermore at the time of shipment, when initial setting is completed, the field of presetting data may be eliminated, and this field can be used as a record playback field of user data. Therefore, it means that equipment capacity had increased and deployment diversification use of

memory can be aimed at. Moreover, since presetting information can fully be taken, the constant amendment means 24 inside an equalizer is realizable with a very easy configuration. On the other hand, even when initializing for every power up, and a magnetic parametric performance changes a lot with time, it can respond appropriately.

[0017]

[Effect of the Invention] In this invention, an automatic equalizer including wave processing of PR is realized. By this, simplification of a circuit can be achieved and IC-ization can offer an easy regenerative-signal processing circuit. By furthermore applying the signal processing IC using this signal processing, a smaller magnetic recorder and reproducing device can be offered.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the basic configuration of the example of this invention, and is the 1st example Fig.

[Drawing 2] Drawing showing the 2nd example of this invention.

[Drawing 3] Drawing showing the 3rd example of this invention.

[Drawing 4] Drawing showing the 4th example of this invention.

[Drawing 5] Drawing showing the 5th example of this invention.

[Drawing 6] Drawing showing the configuration of the automatic equalizer of the 5th example of this invention.

[Drawing 7] Drawing showing the conventional technique.

[Description of Notations]

1 -- Magnetic disk, 2 -- The magnetic head, 3 -- Regenerative-signal processing circuit, 4 -- The identification error calculation section, 5 -- Identification target pattern change-over section, 6 -- The phase simulation signal generation section, 7 -- Pre amplifier, 8 -- A fixed equalizer, 9 -- AGC

circuit, 10 -- LPF, 11 -- A/D converter, 12 -- An automatic equalizer, 13 -- Discrimination circuit, 14 -- A pattern change-over machine, 15 -- PR pattern converter 16 -- Presetting pattern record memory, 17 -- Simple discrimination circuit, 18 -- Identification constant memory, 20 -- Delay element 21 [ 23 / 12' -  
- The conventional automatic equalizer. / -- The counter group, 24 holding a constant -- Constant amendment means ] -- A multiplier, 22 -- Adder

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